PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F24F 3/14

A1

(11) International Publication Number: WO 99/26025

(43) International Publication Date: 27 May 1999 (27.05.99)

(21) International Application Number: PCT/IL97/00372

(22) International Filing Date: 16 November 1997 (16.11.97)

(71) Applicant (*for all designated States except US*): DRYKOR LTD. [IL/IL]; P.O. Box 17, South Industrial Zone, 30300 Atlit (IL).

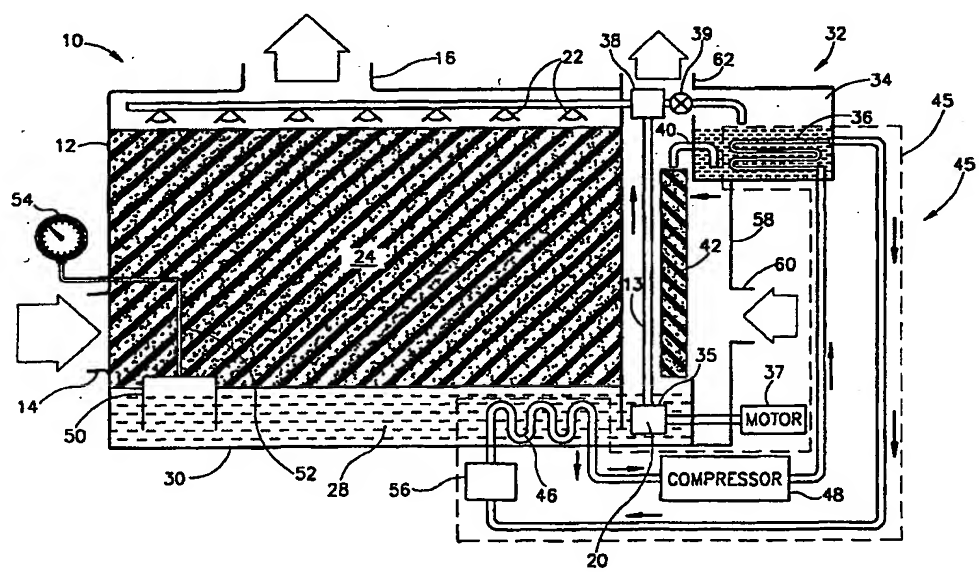
(72) Inventors; and
(75) Inventors/Applicants (*for US only*): FORKOSH, Mordechai [IL/IL]; Derech Hayam Street 58, 31043 Haifa (IL). FORKOSH, Dan [IL/IL]; Hamachtarot Street 9, 30300 Atlit (IL). FORKOSH, Tomy [IL/IL]; Shoshanat Hacarmel Street 54, 34322 Haifa (IL).

(74) Agents: FENSTER, Paul et al.; Fenster & Company, Patent Attorneys Ltd., P.O. Box 2741, 49127 Petach Tikva (IL).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: DEHUMIDIFIER SYSTEM



(57) Abstract

A dehumidifying system (10) which receives moist air and produces dryer air, the system including a reservoir (30) containing a quantity of a desiccant solution (28) at a first temperature; a regenerator (32) in which desiccant solution is heated to a second temperature, higher than the first temperature to remove moisture therefrom; and a heat pump (45) which transfers heat from the desiccant outside the regenerator to desiccant in or traveling to the regenerator. Preferably, heat is transferred from the desiccant in the reservoir (30) which is preferably at a temperature lower than that of the desiccant to which it is being transferred.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

DEHUMIDIFIER SYSTEM

FIELD OF INVENTION

This invention is in the field of dehumidification and in particular is concerned with improved efficiency of desiccant type dehumidifiers.

BACKGROUND OF INVENTION

Large scale air dehumidifying systems based on a desiccating agent are associated with two main problems. One problem is that the dried air output is warmer than the moist air input. This result is caused by the heating of the air from latent heat of evaporation as the moisture is removed therefrom and also, to a lesser degree by the heating of the air by transfer of heat from the generally warmer desiccant. A second problem is that regeneration of the desiccant requires considerable energy.

Dehumidifying systems based on liquid desiccants dehumidify air, by passing the air through a tank filled with desiccant. The moist air enters the tank via a moist air inlet and dried air exits the tank via a dried air outlet. In one type of desiccant system a shower of desiccant from a reservoir is sprayed into the tank and, as the desiccant droplets descend through the moist air, they absorb water from it. The desiccant is then returned to the reservoir for reuse. This causes an increase in the water content of the desiccant.

Water saturated desiccant accumulates in the reservoir and is pumped therefrom to a regenerator unit where it is heated to drive off its absorbed water as vapor. Regenerated desiccant, which heats up in this process, is pumped back into the reservoir, for reuse. Since the water absorption process leads to heating of the air and the regeneration process heats the desiccant, substantial heating of the air takes place during the water absorption process.

An example of a device using a circulating hygroscopic liquid such as a LiCl desiccant is described in US Patent No. 4,939,906. In this patent a boiler is provided with finned tubes

for the flow of the heated desiccant. This patent also discloses pre-heating the saturated desiccant before it enters the boiler for final regeneration by transfer of heat thereto from desiccant leaving the boiler.

Other variations of systems using re-circulated desiccant solutions for dehumidifying air are shown in US Pat. Nos. 4,635,446, 4,691,530 and 4,723,417. Many of these systems utilize transfer of heat from one portion of the dehumidifier to another to improve its efficiency.

In general, regeneration of the liquid desiccant requires its heating with the concomitant expenditure of energy.

SUMMARY OF INVENTION

The present invention is designed to utilize heat transfer in a new way in the process of regenerating its liquid desiccant thereby enhancing the overall efficiency of the system.

In a preferred embodiment of the invention a heat pump extracts heat from liquid desiccant, preferably in a humidity collector unit and transfers it to a heating coil in a regenerator unit thereby reducing the overall energy required by the system. In addition, this transfer of energy has the effect of cooling the desiccant which contacts the moist air that enters the system. Thus, dry air which exits the system is cooler than it would be in the absence of the heat transfer.

In addition, in preferred embodiments of the invention, heat energy in one or more of moisture laden air which exits the regenerator, heated desiccant which exits the regenerator and air which exits the dehumidifier is used to heat the desiccant to be regenerated either on its way to or in the regenerator tank.

There is thus provided, in accordance with a preferred embodiment of the invention a dehumidifying system which receives moist air and produces dryer air, the system comprising:

a reservoir containing a quantity of a desiccant solution at a first temperature;

a regenerator in which desiccant solution is heated to a second temperature, higher than the first temperature to remove moisture therefrom; and

a heat pump which transfers heat from the desiccant outside the regenerator to desiccant in or traveling to the regenerator.

In a preferred embodiment of the invention the heat pump transfers heat from the desiccant in the reservoir to the desiccant in the regenerator.

Additionally or alternatively, the desiccant from which the heat is being transferred is preferably at a lower temperature than the desiccant to which it is being transferred.

Preferably, the system includes means for transferring desiccant from the reservoir to the regenerator when it is desired to remove moisture therefrom. Preferably, the system includes means for transferring regenerated desiccant having a reduced moisture content from the regenerator to the reservoir.

In a preferred embodiment of the invention, the desiccant from which heat is being transferred is regenerated desiccant leaving the regenerator. Preferably the heat is transferred to desiccant being transported to the regenerator. Preferably regenerated desiccant leaving the heat pump is at a lower temperature than desiccant leaving the heat pump to the regenerator.

A preferred embodiment of the system includes means for transferring heat from the regenerated desiccant being transferred to the regenerator.

In a preferred embodiment of the invention, in which moist incoming air is brought into contact with desiccant from said reservoir, said moist air being thus dried, the system includes a heat transfer device which transfers energy from said dried air after it exits the dehumidifier to desiccant entering or within said regenerator. In a preferred embodiment of the

invention, the dried air is at a lower temperature than the desiccant to which heat is transferred from the dried air.

In a preferred embodiment of the invention the system includes a heat transfer device which transfers heat from the moisture removed from the desiccant by the regenerator to desiccant entering or within said regenerator. Preferably, said moisture is at a lower temperature than the desiccant to which heat is transferred from the dried air.

In a preferred embodiment of the invention the dry air exiting the dehumidifier is at substantially the same temperature as or cooler than the moist air entering the dehumidifier.

BRIEF DESCRIPTION OF DRAWING

The present invention will be more clearly and fully understood from the following detailed description of the preferred embodiments thereof, read in conjunction with the drawing in which:

Fig. 1 shows a dehumidifier unit, in accordance with a preferred embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A dehumidifying system 10, in accordance with a preferred embodiment of the invention comprises, as its two main sections, a dehumidifying chamber 12 and a regenerator unit 32. Moist air enters dehumidifying chamber 12 via a moist air inlet 14 and dried air exits chamber 12 via a dry air outlet 16.

In a preferred embodiment of the invention, desiccant 28 is pumped by a pump 20 and associated motor 37 from a desiccant reservoir 30 via a pipe 13 to a series of nozzles 22. These nozzles shower a fine spray of the desiccant into the interior of chamber 12, which is preferably filled with a cellulose sponge material 24 such as is generally used in the art for such purposes. The desiccant slowly percolates downward through the sponge material into

reservoir 30. Moist air entering the chamber via inlet 14 contacts the desiccant droplets. Since the desiccant is hygroscopic, it absorbs water vapor from the moist air and drier air is expelled through outlet 16. Preferably, reservoir 30 is located on the bottom of chamber 12 so that the desiccant from sponge 24 falls directly into the reservoir.

A divider 38 receives desiccant from pipe 13 and sends part of the desiccant to nozzles 22 and part to regenerator unit 32. A valve or constriction 39 (preferably a controllable valve or constriction) may be provided to control the proportion of the desiccant which is fed to regenerator 32. If a controllable valve or constriction is used, the amount of desiccant is preferably controlled in response to the amount of moisture in the desiccant.

Regenerator 32 preferably comprises a chamber 34, which chamber 34 preferably comprises a heater (not shown) and a heat exchanger 36 which heat the desiccant to drive off part of the water vapor it has absorbed, thus regenerating it.

Regenerated liquid desiccant is transferred back to reservoir 30 via a pipe 40 and a tube 42 of sponge material such as that which fills chamber 12. Tube 40 is preferably contained in a chamber 58 which has an inlet 60 and an exit 62. Air enters chamber 58 via inlet 60 and carries away additional moisture which is evaporated from the still hot desiccant in tube 42. Air exiting at exit 62 carries away this moisture and also moisture which was removed from the desiccant in the regenerator. Preferably a fan (not shown) at exit 62 sucks air from chamber 58.

Alternatively or additionally, heat is transferred from the regenerated liquid desiccant to the desiccant entering or in regenerator 32 by bringing the two desiccant streams into thermal (but not physical) contact in a thermal transfer station (not shown). Alternatively or additionally, a heat pump may be used to transfer additional energy from the hotter desiccant to the cooler one, such that the desiccant returning to reservoir 30 is actually cooler than the desiccant which enters chamber 34.

In a preferred embodiment of the invention, a heat pump system 44, indicated by a dotted line 45, is provided which extracts heat from the desiccant in reservoir 30 to provide energy to heat exchanger 36. Preferably, heat pump system 44 includes (in addition to exchanger 36 which is the condenser of the system) a second heat exchanger 46 in reservoir 30, which is the evaporator of the system, and an expansion valve 56. This transfer of energy results in a reduced temperature of the desiccant which contacts the air being dried thus reducing the temperature of the dried air. Second, this transfer of energy reduces the overall requirement of energy for operating the regenerator by up to a factor of 3. Since the energy utilized by the regeneration process is the major energy requirement for the system, this reduction in energy usage can have a major effect on the overall efficiency of the system. Additionally, this method of heating of the desiccant in the regenerator may be supplemented by direct heating, utilizing a heating coil (not shown).

It should be understood that the proportion of water vapor in the desiccant in reservoir 30 and in the regenerated desiccant must generally be within certain limits, which limits depend on the particular desiccant used. A lower limit on the required moisture level is that needed to dissolve the desiccant such that the desiccant is in solution in the moisture. However, when the moisture level is too high, the desiccant becomes inefficient in removing moisture from the air which enters chamber 12. Thus, it is necessary that the moisture level be monitored and controlled. It should be noted that some desiccants are liquid even in the absence of absorbed moisture. The moisture level in these desiccants need not be so closely controlled. However, even in these cases the regeneration process (which uses energy) should only be performed when the moisture level in the desiccant is above some level.

This monitoring function is generally performed by measurement of the volume of desiccant, which increases with increasing moisture. A preferred method of measuring the

volume of liquid in the reservoir is by measurement of the pressure in an inverted vessel 50 which has its opening placed in the liquid in the reservoir. A tube 52 leads from vessel 50 to a pressure gauge 54. As the volume of desiccant increases from the absorption of moisture, the pressure measured by gauge 52 increases. Since the liquid in the chamber and in the regenerator is fairly constant, this gives a good indication of the amount of desiccant and thus of the amount of moisture entrained in the desiccant. When the moisture level increases above a preset value, the heater and/or heat pump 44 in chamber 34 are turned on. In a preferred embodiment of the invention, when the moisture level falls below some other, lower preset value, the heater is turned off.

Other factors which may influence the cut-in and cut-out points of the regeneration process are the temperature of the dry air, the regeneration efficiency and the heat pump efficiency. In some preferred embodiments of the invention, especially in cold air systems (as for ice-skating rinks) it may be advisable to provide some direct heating of desiccant in the regeneration process.

In other preferred embodiments of the invention heat pumps or other heat transfer means (not shown for simplicity) are provided to transfer heat from the dried air exiting chamber 12 and or from the heated moist air leaving regenerator chamber 34, to heat the desiccant on its way to or in chamber 34. If heat pumps are used, the source of the heat may be at a temperature lower than the desiccant to which it is transferred.

It should be understood that cooling of the desiccant in the reservoir can result in dried air leaving the dehumidifier which has the same, or preferably a lower temperature than the moist air entering the dehumidifier, even prior to any additional optional cooling of the dry air. This feature is especially useful where the dehumidifier is used in hot climates in which the ambient temperature is already high.

The present invention has been described utilizing a preferred embodiment thereof. It should be understood that many variations of the preferred embodiment within the scope of the invention, as defined in the following claims, are possible and will occur to a person of skill in the art.

CLAIMS

1. A dehumidifying system which receives moist air and produces dryer air, the system comprising:

a reservoir containing a quantity of a desiccant solution at a first temperature;

a regenerator in which desiccant solution is heated to a second temperature, higher than the first temperature to remove moisture therefrom; and

a heat pump which transfers heat from the desiccant outside the regenerator to desiccant in or traveling to the regenerator.

2. A system according to claim 1 wherein the heat pump transfers heat from the desiccant in the reservoir to the desiccant in the regenerator.

3. A system according to claim 1 or claim 2 wherein the desiccant from which the heat is being transferred is at a lower temperature than the desiccant to which it is being transferred.

4. A system according to any of the preceding claims and including means for transferring desiccant from the reservoir to the regenerator when it is desired to remove moisture therefrom.

5. A system according to claim 4 and including means for transferring regenerated desiccant having a reduced moisture content from the regenerator to the reservoir.

6. A system according to claim 5 wherein the desiccant from which heat is being transferred is regenerated desiccant leaving the regenerator.

7. A system according to claim 6 wherein the heat is transferred to desiccant being transported to the regenerator.

8. A system according to claim 7 wherein regenerated desiccant leaving the heat pump is at a lower temperature than desiccant leaving the heat pump to the regenerator.

9. A system according to any of claims 1-5 and including means for transferring heat from the regenerated desiccant being transferred to the regenerator.

10. A system according to any of the preceding claims in which the moist incoming air is brought into contact with desiccant from said reservoir, said moist air being thus dried and including a heat transfer device which transfers energy from said dried air after it leaves the dehumidifier to desiccant entering or within said regenerator.

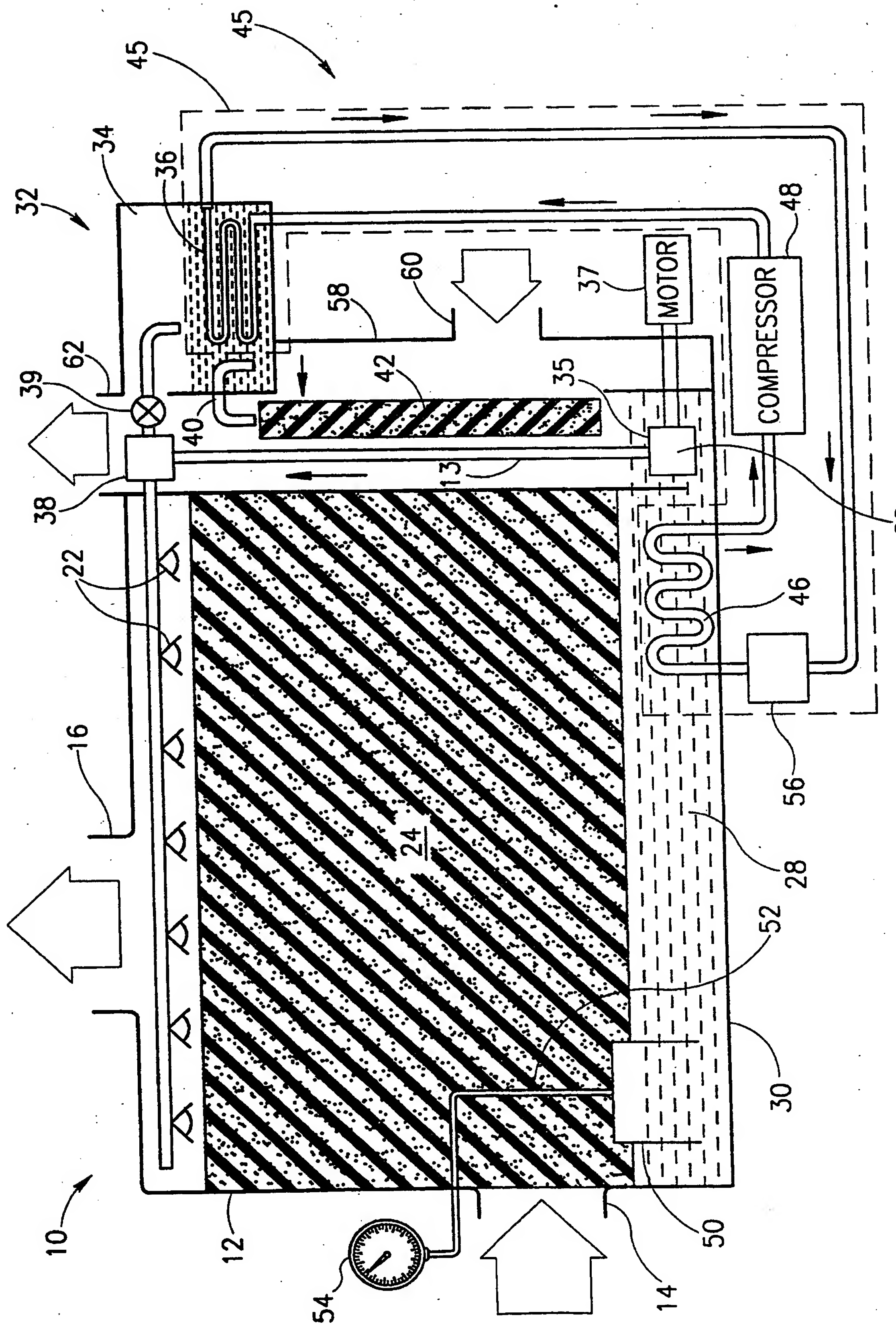
11. A system according to claim 10 wherein said dried air is at a lower temperature than the desiccant to which heat is transferred from the dried air.

12. A system according to any of the preceding claims and including a heat transfer device which transfers heat from the moisture removed from the desiccant by the regenerator to desiccant entering or within said regenerator.

13. A system according to claim 12 wherein said moisture is at a lower temperature than the desiccant to which heat is transferred from the dried air.

14. A system according to any of the preceding claims wherein the dry air exiting the dehumidifier is cooler than the moist air entering the dehumidifier.

15. A system according to any of claims 1-13 wherein the dry air exiting the dehumidifier is at substantially the same temperature as moist air entering the dehumidifier.



MOTOR
COMPRESSOR
10
12
13
14
16
20
22
24
28
30
32
34
35
36
37
38
39
40
42
45
46
48
50
52
54
56
58
60
62

FIG.1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 97/00372

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F24F3/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F24F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 4 984 434 A (PETERSON JOHN L ET AL) 15 January 1991 see the whole document	1-4, 9-12,14 5,13,15
A	US 4 939 906 A (SPATZ MARK W ET AL) 10 July 1990 cited in the application	1
A	US 4 430 864 A (MATHIPRAKASAM BALAKRISHNAN) 14 February 1984	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 July 1998	09/07/1998

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gonzalez-Granda, C

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IL 97/00372

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4984434 A	15-01-1991	US 4941324 A	17-07-1990
US 4939906 A	10-07-1990	NONE	
US 4430864 A	14-02-1984	NONE	